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VOLUME XXIII NUMBER 6

THE

JOURNAL OF GEOLOGY

SEPTEMBER-OCTOBER 1915

SOME EVENTS IN THE EOGENE HISTORY OF THE PRESENT COASTAL AREA OF THE GULF OF MEXICO IN TEXAS AND MEXICO

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EOGENE SECTION

The most complete section of the Eogene[1] deposits of the eastern border of North America is found in Alabama and Mississippi, but even this is somewhat indefinite in its upper members and only by supplementing these with their marine representatives of the Florida region can the entire section be clearly understood

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[1] Used as inclusive of both Eocene and Oligocene.

Thus constructed, the section would be:

	Alabama-Mississippi	Florida
Oligocene:	Grand Gulf	Tampa
	Ocala	Chattahoochee
	Vicksburg	
Eocene:	Jackson	
	Claiborne	
	Wilcox	
	Midway	

The deposits as a whole are those of marine waters alternating with estuarine and fresh-water conditions, and the fossils indicate uniformly a warm or subtropical temperature of water.[1]

The time relations of the various members of these groups can be best made out in such an area of apparently continuous sedimentation as that found in this typical area, but when, as in this case, a study of the faunas of the various members indicate great physical changes intervening between them, further evidence of such changes is to be looked for in the extensions of the deposits. Some important evidence of this character is to be found in the Texas-Mexican region (Fig. 1).

CRETACEOUS-TERTIARY BARRIER

Prior to the deposition of the earliest Tertiary sediments in this area the Cretaceous rocks had been subjected to vulcanism, folding, and erosion. These movements began during the period of the Austin Chalk, at which time a barrier of some sort was created in the vicinity of the Salado and Sabinas rivers in northeastern Mexico which formed the beginning of what has been called the Rio Grande embayment. To the north of this barrier the succeeding Cretaceous sediments are largely clays and sands and include the coal beds of the Rio Grande region, while to the south we find only a great thickness of blue and black shales. The beds to the north are frequently very fossiliferous, while the shale beds are, so far as known, practically destitute of any trace of fossils.

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[1] Dall, *Trans. Wag. Inst.*, p. 1549.

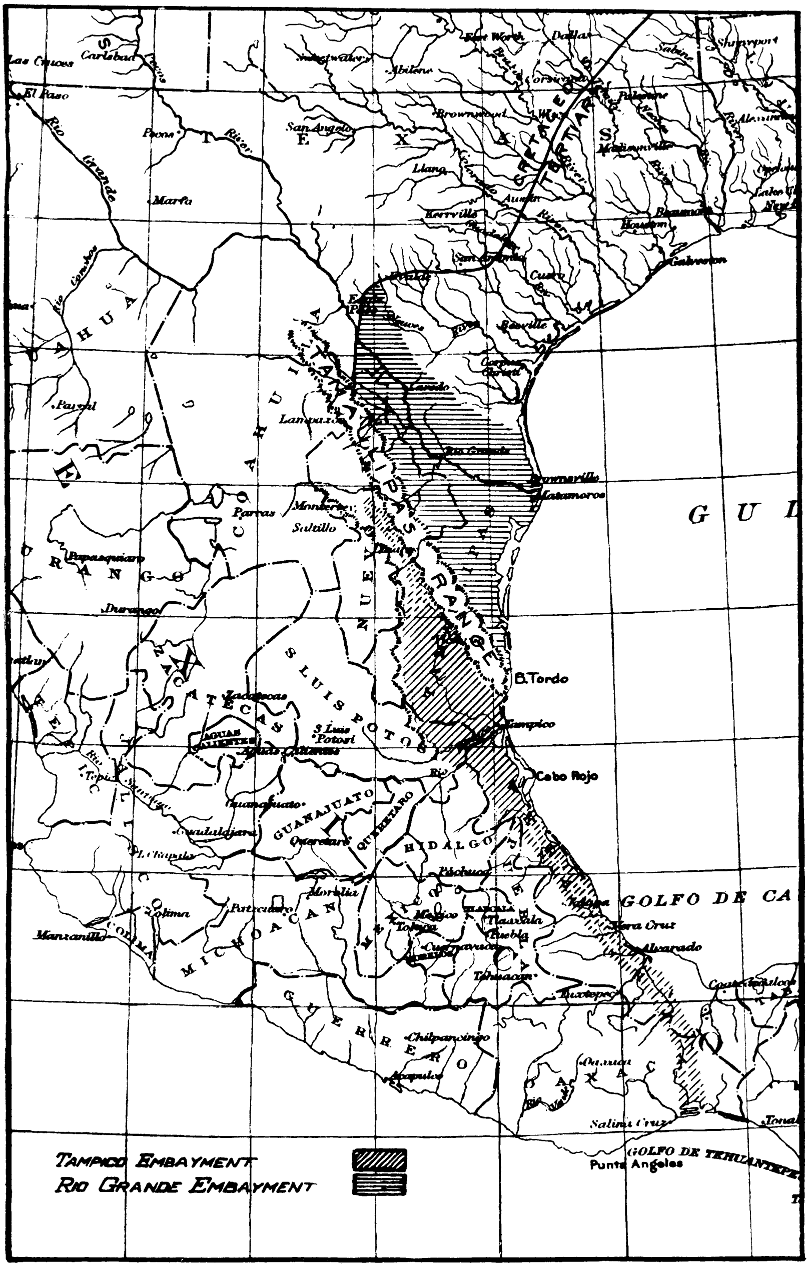

FIG. 1. Barrier in Gulf Coast region separating Atlantic and Pacific waters in Cretaceous-Tertiary times.

This movement was marked in the Texas area by Pilot Knob and other volcanoes south of Austin, which were active during the close of the Chalk deposition and the beginning of the Taylor marls, as is shown by the ash from them, which is interstratified with, and included in, these deposits.

At the close of the Cretaceous the movement was intensified and resulted in a land barrier which is now marked by the disconnected ranges and groups of hills that form the eastern border of the valley lying at the foot of the Mexican Cordilleras.

These groups and ranges include the San Antonio, San Juan, Vallecillo, Picachos, Papagallos, San Carlos, and Tamaulipas, for which, as a whole, Professor Cummins has proposed the name of the Tamaulipas range. Since the trend of the coast in this region is a little west of south, the southeast course of this Tamaulipas Range brings it rapidly nearer the Gulf. At Tordo Bay, some fifty miles north of Tampico, the main body of the hills is within ten miles of the coast, while outliers extend almost to the water's edge.

This range is made up of shales and limestones, more or less altered and disturbed by folding and by igneous rocks. No fossils have been found in the shales, but the limestones yielded a few *inocerami* and fragments of *Ammonites*. Dr. Stanton, who examined these, states that these limestones are not younger than the Taylor marls and may not be younger than the Austin Chalk.

The Tamaulipas Range represents the extension southward and culmination of the movement creating the Sabinas barrier, and just as the Sabinas barrier forms the southern limit and border of the Gulf Coast Cretaceous deposits, so does the Tamaulipas Range form the southern border and limit of the Gulf Coast Eocene. The difference in the character of deposits laid down in late Cretaceous time to the north and south of the Sabinas barrier is just as strongly shown in the difference between the Eocene deposits east of the Tamaulipas Range and those of the same age which are found to the west and south of it, since not only are the deposits themselves of different character, but even the fossils which the latter carry are entirely unlike those to the north.

CRETACEOUS-TERTIARY CONTACT

South of the Salado River the exposures of the Cretaceous shales along the line of contact with the Tertiary indicate that they have been subjected to more or less folding and to erosion prior to the incursion of the waters of the Eocene, so that the contacts from Rodriguez south show very decided unconformities.

On the Rio Grande the unconformity is shown partly by difference in direction of dip and partly by the fact that the Midway is found resting upon different members of the Escondido.

Northward from the Rio Grande the uppermost beds of the Cretaceous present, as a whole, a gentle slope toward the Gulf, and when we find contacts between these beds and the basal Tertiary the discordance of stratification is usually very small, even if it be present at all. There is, nevertheless, ample proof of folding in this area also, for logs of wells drilled in the Tertiary belt of western Louisiana and eastern Texas give positive evidence of broad folds in the underlying Cretaceous beds far to the seaward of their present outcrop.

The most striking feature of the orogenic movement in this area is, however, found in the numerous submerged hills of the salt domes that now occur as inliers in the Tertiary belt. These, as shown by the discordance of dip between the Cretaceous rocks and those of the surrounding Eocene, are pre-Tertiary.

LOWER EOCENE

Midway.—The initial sediments of the Eocene were marine and are fairly uniform in character throughout their entire extent within the area of the western Gulf Coast. While east of the Brazos they occupy a belt which has at times a width of several miles, with a total thickness of between 300 and 400 feet, west of that stream they are found in disconnected exposures due generally to the overlapping of later deposits.

This is clearly shown on the Rio Grande, where excellent contacts have been found by Kennedy, and where this substage attains a thickness of 300 feet. Here the Midway is frequently covered both by the Wilcox or Lignitic and by the Carrizo sands or basal Claiborne.

These conditions continue to the Salado River, but south of that stream the Midway covers a much larger surficial area and the Wilcox and Carrizo are less prominent.

By far the best exposures of the Midway which we have found are those in the valley of the Salinas River east of Ramones, Mexico. Here they occupy a considerable area and also form the Alto Colorado, a hill 250 feet in height which is composed entirely of Midway sediments. These have a total thickness of more than 400 feet. Among the fossils found in some abundance are *Ostrea pulaskensis*, *O. crenulimargo*, *Venericardia alticosta*, *V. planicosta*.

The last exposure of these beds within this area was found on the road to China, six miles southeast of Ramones.

That the close of the Midway was brought about or accompanied by an uplift is proven in the Rio Grande region, where it is seen to have a greater dip than the succeeding Lignitic series.

Wilcox or Lignitic series.—The series of fresh-water or estuarine deposits which followed the Midway shows little change in the general character of its sediments southwestward, with the exception that south of the Colorado it loses the larger part of the lignitic beds which are such a prominent feature of it north and east of that river.

North and east of the Colorado the Wilcox covers a broad area and has a thickness, as shown by wells drilled through it, of 1,000–1,200 feet. South of this river the exposure gradually becomes narrower and the beds thinner.

Its exposures along the Rio Grande are few and the thickness of the beds exposed probably does not exceed 100 feet. All of its observed contacts with the Midway were unconformable and there is a distinct difference in the degree of dip of the beds of the two stages. The sand and clays of the Wilcox Lignitic show evidence of emergence and erosion and in many places are entirely absent, having evidently been eroded prior to the deposition of the lowest Claiborne sands.

The Lignitic is found within a few miles south of the Rio Grande in a number of exposures. Farther south and beyond the Salinas it overlaps and covers the Midway, so that the latter is seen no more and the Lignitic is itself in contact with the shales of the Cretaceous.

The most southerly exposure of the Lignitic was seen on the Conchos River a mile west of Angeles, where it is uncovered for a short distance by the erosion of that stream.

At the close of the Lignitic its sediments emerged and were strongly eroded prior to the incursion of the Claiborne sea.

In Lower Eocene time, therefore, the area north of the Tamaulipas Range was submerged and marine waters prevailed as far south as the latitude of Monterey. At the close of this period the marine waters receded and after a period of erosion were followed by the submergence of the deposits under fresh or brackish waters. The close of this second or brackish-water period of sedimentation was followed by its emergence and erosion.

In the region west and south of the Tamaulipas Range no deposits have been found which can certainly be referred to the Lower Eocene as represented north of that range by the Midway and Wilcox.

Beginning near the foot of the high plains of the interior of Mexico there is a series of blue and gray shales which have a wide development, forming a large part of the surface rock of the valley between the Cordilleras and the Tamaulipas Range and continuing southward beyond the Tuxpam River as far as examinations were carried. In the northern part of this area these shales have been traced to a direct connection with those found in the San Juan and Papagallos mountains, which, by their relations to the basal Tertiary and the fossils found in limestones immediately underlying them, were proved to be Upper Cretaceous.

There is undoubtedly a great thickness of these shales, but no fossils have ever been found in them. There is, therefore, a possibility that in their upper portion some representative of early Eocene time may be present, but, if so, it has not yet been differentiated.

So far as yet recorded no fossils characteristic of the Midway or Lignitic have been found between Tordo Bay and Yucatan, although fossils of both periods are known to exist in Venezuela and elsewhere to the south.

MIDDLE EOCENE

Buhrstone and Claiborne.—In the Alabama section the Buhrstone and Claiborne have a total thickness of about 450 feet, the Claiborne proper being only one-third of this amount. The surface exposures rarely exceed a total width of fifteen miles. In Texas the narrowest portion of this Claiborne belt occurs on the Colorado River and has a width of twenty-five miles, which widens northeast to ninety miles on the Neches and attains a similar width southwestward in the Rio Grande region. Along the Rio Grande, which crosses the formation obliquely to the dip, the belt has an exposure of 150 miles. The beds in Texas also have a correspondingly increased thickness and have been divided as follows: the Carrizo sands corresponding to the Buhrstone; the Marine, Yegua, Fayette, and Frio substages—all of which carry fossils characteristic of the Lower Claiborne. These substages are present from the Conchos or Presas River in Mexico to the Colorado in Texas. The Frio has not been recognized east of the Colorado, and east of the Neches the Fayette is also wanting, except as isolated patches, owing to pre-Jackson erosion.

The Carrizo sands which mark the beginning of the Middle Eocene deposition are the stratigraphic continuation of the Queen City beds of northeast Texas. Throughout this region where Kennedy first observed them, the relations of these sands to the underlying Lignitic is such that he considered them to be the upper member of that stage and so described them. Later examinations in the western part of the state, however, brought out the fact that the Carrizo sands were entirely unconformable with the Lignitic deposits and that in some localities they grade upward into the basal beds of the Marine substage.

In Northeastern Texas the Carrizo sands have a thickness of 70 feet and appear to be conformable with the Lignitic. On the Atascosa the contact was not observed, but the sands were apparently of much greater thickness. On the Rio Grande the beds are exposed over a very wide area, outcropping along the river for a distance of forty miles. They have a less marked dip than either the Lignitic or Midway and are found resting on both of these and overlapping them to contacts with the Escondido beds and the Papagallos shales of the Cretaceous.

South of the Rio Grande the Carrizo sands are well exposed and form the crest and eastern slope of various small groups and ranges of hills lying between the Rio Grande and Azulejo and of the larger range south of that point, known as the Ceja Madre. These hills have a total length of about ninety miles and reach nearly to the Salado River.

South of the Salado the Carrizo is not so prominent and was observed only in a few localities.

The Marine beds in places, as on the Rio Grande and the Atascosa, are directly connected with the Carrizo sands by transitional beds of lignitic shales, but at other places, and especially in east Texas, no such connection can be found and beds of greensand or of brown sandstone are directly superposed upon the Carrizo, although usually without apparent unconformity. Local movements during Marine time are, however, registered in the sediments in some parts of the area.

The Marine beds have a thickness of 800–1,000 feet. The eastern portion of the deposits seems to have been most highly glauconitic, although the beds everywhere give evidence of the presence of this mineral in greater or less quantity.

In the eastern portion of the state the alteration of this glauconite has resulted in the formation of extensive deposits of excellent iron ores, but in the western portion the resulting ferruginous matter is widely disseminated and simply forms a cement for the brown ferruginous sandstone which covers such a great area in Southwestern Texas.

On the Rio Grande the carbonaceous shales of the Carrizo find their culmination in the San Pedro and San Tomas beds of cannel coal between which are beds bearing characteristic Claiborne fossils.

The exposure of the Marine beds on the Rio Grande has a width of more than fifty miles. They narrow rapidly to the south and where they cross the Salado west of Guerrero the outcrop is not more than five or six miles wide.

They are well shown in the valley of the San Juan and are traceable for twenty-five miles south of that stream, when they are covered by the Yegua. They are not observed on the Conchos.

Fossils are abundant throughout the entire extent of the substage, although the upper portion is usually the most fossiliferous portion. In the Texas area in addition to the characteristic fauna we find a few forms practically identical with those of the Tejon. In the San Juan region, associated with the *Venericardia planicosta*, there are found vast numbers of a varietal form very similar to, if not identical with, *V. potopacoenses* of the Maryland Eocene.

The succeeding substage, the Yegua clays, appears to be unconformable with the Marine. The Yegua deposits are predominatingly lignitic clays, but comprise beds of sands and greensands as well. They, unlike the earlier Lignitic, maintain their thickness of 1,000–1,400 feet and carry their deposits of lignite entirely across the state. They are also the principal gas-bearing beds of the Eocene. Like the lower Lignitic, they become more sandy on the Rio Grande and this condition persists throughout exposures south of the river to Mendez on the Conchos or Presas.

In their eastern part these beds are not as fossiliferous as they are west of the Guadalupe, although they carry fossils in many places, especially between the Brazos and the Colorado. On the Rio Grande they are nearly as fossiliferous as the Marine.

It has been suggested that the so-called Cocksfield Ferry beds on the Sabine might be of Upper Claiborne age, but they have been connected by careful tracing with the basal Yegua and are, therefore, Lower Claiborne.

To these deposits of Yegua clay there succeeded another substage, the Fayette, which, while it carries beds of lignitic clays and sands with some lignite, is principally composed of sands and sandstones. Some of the sands are friable while others are quartzitic and they carry a considerable amount of fossil wood which is opalized instead of being simply silicified. They have a thickness of 500–600 feet.

East of the Guadalupe, with rare exception, the Fayette does not carry any fossils except the wood, but west of that stream it contains the large oyster, *O. alabamiensis var. contracta* of Conrad, which is one of its most characteristic forms. On the Nueces and Rio Grande we find, besides this oyster, numerous other forms which link it positively with the Claiborne. This is especially true of the exposures on the Rio Grande which have a width of fully forty miles with many fossil beds. These include:

Venericardia planicosta, Lam.
Anomia ephippioides, Gabb.
Leda opulenta, Con.
Crassatella protexta, Con.
Tellina mooreana, Gabb.
Cytherea bastropensis, Har.
Conus sauridens, Con.
Volutilithes petrosus, Con.
Levifusus trabeatoides, Har.
Lacinia alveata, Con.
Pseudoliva vetusta, Con.
Turritella nasuta, Gabb.

South of the Rio Grande it is found in a broad belt extending southeastward by way of Mier, Aldamos, China, and Mendez to the Conchos and beyond as far as the Chorreras, where it finally passes under cover of the Oligocene.

Between the Conchos and the Chorreras the Fayette apparently forms a portion of Mt. Corcovada east of Burgos, being elevated by a basaltic extrusion.

The Frio clays which follow are found overlying the Fayette sands from the Conchos River to the Guadalupe. On the Conchos and on the Ramones Mountains lying north of it they show a considerable thickness of yellow and darker clays which weather white and are accompanied by considerable quantities of disseminated gypsum and also beds of this material. Farther north the Frio beds are not so thick and in many places only a few feet of the formation are found between the sands of the Fayette and the overlying Oakville sands of Miocene age. Such fossils as have been found are apparently of Claiborne age and the clays are, therefore, referred to that stage.

The Middle Eocene of this Gulf area represents a succession of alternating marine, lagunal, and swamp conditions. The marine conditions were most constant in the Rio Grande region and farther south, while in the eastern portion of the state the lagunal and swamp conditions apparently predominated.

There are unconformities here and there and evidences of local warping of the strata in the various substages, but they are, nevertheless, bound together by transitional beds or identity of fossils.

The constantly changing conditions of deposition in the region east and north of the Tamaulipas range during Middle Eocene time, as shown by the variableness of the deposits above described, did not extend to the region lying west and south of that range.

West of the Tamaulipas Range the blue shale of the uppermost Cretaceous is followed by other shales so similar in general character that only the finding of Eocene fossils in them suggested the differentiation of the two.

The only localities where exposures of these beds have certainly been found is in the vicinity of Alazan, on the Buena Vista River, about twenty-five miles northwest of Tuxpam.

The deposits are bluish shales that weather white or yellow and their exact relations to the Cretaceous were not determined, on account of the inadequate exposures. The fossils are widely scattered through the shale and it is possible to collect them in good condition only from decomposed fragments of the rock.

This locality was discovered by Mr. DeGolyer and fossils found by him were recognized by Dr. Dall as Pacific Coast forms. It was afterward visited by Professor Cummins, who made a somewhat larger collection of the fossils. These were also submitted to Dr. Dall and afterward turned over to Professor Roy E. Dickerson for study in connection with other Pacific Coast faunas of Eocene age in his work at the University of California.

The collection of fossils made at this locality by Professor Cummins comprises a fauna consisting principally of gasteropods and small bivalves. The preliminary examination failed to show any forms which could be referred to our Claiborne, but did show some that were apparently identical with, and many that were very similar to, Eocene Tejon of California.

These beds dip eastwardly and probably extend some distance north and south of Alazan. Shales similar to these were observed along the railroad north of the Panuco River and on the San

Antonio River west of Cruz, a station on the railway between Tampico and Monterey. Cummins correlates these shales north of Panuco and west of Cruz with the Alazan deposits because of common lithological character, although he found no fossils in them.

They were, however, certainly found in drilling a well at Topila, on the Panuco River, at a depth of 1,810 feet, as shown by the fossils brought up with the drill. Of the fifteen species collected at this locality nearly one-half are identified as Tejon species and the others as nearly related to them.[1]

UPPER EOCENE

So far we have not positively recognized the Frio clays, which are the uppermost beds referable to the Middle Eocene, east of the Colorado. Other beds of clay have been referred to this substage, but closer investigation seems to show that the Frio clays are not present in eastern Texas. Growing out of such correlation it has been presumed that both the Fayette and Frio of eastern Texas are later than the Lower Claiborne and correspond with the Jackson and the Oligocene.

In the area west of the Colorado River, where these beds have had closest study and where they are most fossiliferous, it is very certain that this presumption is erroneous. There is a continuity of the Lower Claiborne fauna through these upper beds and no forms whatever of Jackson or later age have been observed.

In all this area the Frio is found resting seemingly upon an uneroded surface of Fayette sands and north of the Rio Grande it is unconformably overlain by the Oakville Miocene without beds of either Upper Eocene or Oligocene age intervening.

East of the Guadalupe River the conditions are somewhat different. In the valley of the Colorado and eastward to the Sabine it is evident that subsequent to the deposition of the Frio and prior to the beginning of Jackson deposition as now known, there was a period of erosion during which the Frio, more or less of the Fayette, and even a part of the Yegua were carried away. This erosion probably took place during the deposition of the Upper

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[1] *Science*, XXXV, 906–8.

Claiborne sediments in other regions and appears not to have greatly affected that portion of our Claiborne belt lying between the Guadalupe in Texas and the Conchos in Mexico. During these oscillations of the land it is evident that the relief at any time was slight.

Jackson.—Beginning west of Groveton, in Trinity County, Texas, in the valley of the Neches, and stretching eastward to the Sabine is a belt eight or ten miles in width in which are found calcareous clays and sands with nodules and bands of impure limestone, carrying fossils of Jackson age. For the most part these deposits lie directly upon the clays of the Yegua, since only occasionally are the Fayette sands to be found between them.

The identity of these deposits is clearly evident from the considerable number of fossils found at various localities.

The Jackson sediments have not been found west of Groveton. In their place, however, the Fayette sands gradually assume their normal position in the section, showing less and less erosion, until the Colorado drainage is reached.

The Jackson shore line may have extended westward as far as the Brazos, for sands thought to be at the top of the Fayette near Wellborn have yielded fossils which are now said to be of Jackson age, although originally the collections were classed as Lower Claiborne.

These are supposed to be, however, a lower horizon in the Jackson than the deposits farther east.

In southeastern Texas we have found indications of the gulfward extension of the Jackson deposits in fossils from oil wells drilled at Saratoga and Sour Lake, but southwest of the Brazos no indications whatever of any materials of this age are known either in Texas or in Mexico.

We have, therefore, in this eastern Texas area simply the western limit of the Jackson deposition and the materials themselves in many places give evidence of the near-shore conditions.

Almost nothing has been found in this area that throws light on the happenings between the close of the Middle and Upper Eocene and the beginning of Oligocene deposition. Whatever there may have been is covered by the succeeding beds of the Oakville.

OLIGOCENE

Nowhere within the Texas area has any trace of Vicksburg strata been found, but Hilgard and Loughridge both contended that the Grand Gulf sandstones were found along the Sabine, and Loughridge traced them nearly across the state.

There is a belt of sandstone crossing the state just as described by this observer and it has some of the lithologic characteristics of the Grand Gulf. Our investigations seem to indicate, however, that while it may be traced in apparent continuity across the area it is in reality not homogenous, but is in fact a composite series. That it represents in part remnants of a deposit of the Grand Gulf sands, even if not fully susceptible of proof, is strongly probable. We also know that it comprises beds of later deposition which have surrounded and overlapped these Grand Gulf remnants. These later deposits are the Oakville sands of western Texas and are of Miocene age. Among the outcrops now remaining which we think are Grand Gulf are those at Colmesneil, the quarry north of Corrigan, near Riverside, etc.

The lack of fossils in the Grand Gulf sands and the close resemblance to them (even including the quartzitic phases) of those of Oakville age will probably prevent any complete differentiation of the two, although this may be done in part through a study of the scanty flora occurring in them here and there.

If any other Oligocene deposits besides the remnants of the Grand Gulf were laid down in the Texas area they have been eroded or are also covered by the overlap of the Oakville.

In Mexico, on the contrary, we find a broad development of the Marine facies of the Oligocene deposits such as are found in Florida and the Antilles as distinguished from the near shore brackish-water phase of most of the Gulf area.

North of the Tamaulipas Range we find, overlying the Eocene, a series of yellow sands, clays, and calcareous beds which carry an abundant Oligocene fauna. They were first studied in the vicinity of San Fernando, on the Conchos River, where there are fine exposures, and we have called this local development of the beds the San Fernando.

These Oligocene deposits are found resting upon the Frio clays along the Conchos River and the eastern front of the Pomeranes Range, and they extend northward to within fifty miles of the Rio Grande, beyond which point we find no trace of them, possibly because of the extensive development of the Reynosa surficial deposits in that region.

South of Abasola the Oligocene overlaps the Frio and is in direct contact with the Papagallos shales on the west and extends eastward to the Gulf shore.

The corals found in some of these beds have been studied by Dr. Vaughan, who says that they indicate an Upper Oligocene horizon, about equivalent to the Chattahoochee of Georgia. This is borne out by such of the molluscan remains as have been examined, and so far our collections from this area have not yielded any forms characteristic of the Lower Oligocene. Among the corals determined are: *Favites* (?) *polygonales* Duncan, *Goniastrea antiquaensis* Duncan, *Acropara* ? sp., *Orbicella cellulosa* Duncan, *Orbicella* n. sp., *Geneopora* sp. very similar to, or identical with, an Antiguan species.

South of the Tamaulipas Range the yellow clays and sands of the Oligocene cover a broad area. Between the Buena Vista River and the Tamiahua Lagoon many exposures are found and the beds are highly fossiliferous. *Cristalleria* and *Nummulites* abound and *Orbitoides papyracea* Bou. is found from the Buena Vista to the Tancochin at Cerro del Oro. Dr. Dall states that this form occurs in the Lower Oligocene beds in Alabama, indicating a Lower Oligocene age for this portion of the deposits. This Oligocene belt has a known width of twenty miles east of the Buena Vista River and has been observed twenty miles west of that stream resting upon the shales of the Cretaceous.

In addition to the fossils named there are many others, including several echinoderms, pectens, and other bivalves and numerous gasteropods.

While a detailed examination of these beds has not been made, enough has been done to prove that there is in this part of Mexico very considerable thickness of these Oligocene deposits and that they represent portions, if not all, of both Lower and Upper Oligocene time. The lower beds, so far as now determined, are confined to the region south of the Panuco, while the upper stretch northward beyond the old Eocene barrier nearly to the Rio Grande.

MIOCENE

In Texas, as we have seen, such Oligocene deposits as may occur are overlain directly by the Miocene (Oakville) and the sands of one are almost indistinguishable from the sands of the other, both being probably of fresh- or brackish-water deposition.

In Mexico the yellow clays and sands of the Oligocene are also overlain by similar yellow clays and sands of Miocene age and the deposits themselves are of very similar character and thus far no evidence of a decided break in sedimentation between them has been found, the only change being in the fossils contained in them, those of the Miocene being characteristically developed in the beds around Tuxpam.

TAMPICO EMBAYMENT

The importance of the Tamaulipas Range as a structural feature is, therefore, clearly shown, and it is now apparent that at the beginning of the Tertiary and through the Eocene the waters of the Mexican Gulf covered only that portion of its present coast line in Mexico which lies north of Tordo Bay about 225 miles south of the mouth of the Rio Grande.

It would also appear that the waters of the Gulf and those of the embayment south of the Tamaulipas Range, although they were evidently separated by a comparatively narrow strip of land, did not have such a connection as would permit a commingling of the two faunas, since they have only four or five forms in common.

The Topila well mentioned above is less than twenty miles from the present shore line of the Gulf of Mexico and is much nearer to its present waters than is any bed of similar age in the region north of the Tamaulipas Range. There is no indication of a barrier to prevent the extension of these deeply buried Alazan beds with their Pacific fauna eastward or southeastward until they actually underlie the present waters of the Gulf. It is clearly evident, therefore, that during the Middle Eocene the Gulf waters did not reach below Tordo Bay on its present coast line, but were held by a barrier or the southeastward extension of the Tamaulipas Range and that part of its present coast in the vicinity of Tampico was occupied by the waters of the Pacific.

The observed facts indicate that during the Middle Eocene the waters of the Atlantic occupied the territory north of the Tamaulipas Range and the waters of the Pacific the region south of that range, and that with the beginning of the Oligocene, the waters of the Atlantic claimed both of these regions. It is therefore evident that the connection between the Pacific Ocean and its Tampico embayment was closed entirely, either during the Upper Eocene or at its close, and that the extension of the present Gulf coast southward from Tordo Bay dates from this period.

While the exact area embraced in this embayment south of the Tamaulipas Range is unknown, its point of connection with the Pacific Ocean was probably near the present Isthmus of Tehuantepec and its western border was formed by the escarpment of the Cordilleras. It is probable that its northerly extension occupied the site of the valley now traversed by the railroad between Tampico and Monterey. The Tamaulipas Range must have formed its eastern boundary in this northern portion, but we have, at present, no idea of its eastern limit farther south beneath the western margin of the present Gulf of Mexico. It seems probable, however, that this Tampico embayment was a body of water not unlike the Gulf of California, both in extent and in trend, and that it made a peninsula of that part of the Republic of Mexico north of the Isthmus of Tehuantepec just as the Gulf of California now makes the peninsula of Lower California.